

Priority Analysis of Green Open Space in Pekanbaru City

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Abstract

Pekanbaru City Government issued a letter of interest to the central government regarding the Letter of Interest in Participating in the Green City Development Program (P2KH). One of the attributes of P2KH is Open Green Space. In 2020, when referring to the Spatial Planning Law, Pekanbaru City should have 12,780,31 ha of green open space to meet the figure of 30% of the city area. However, currently Pekanbaru only has 3,195.08 ha of green open space, which consists of green lanes, cemeteries, city parks, urban forests, and road median parks. Pekanbaru's green open space is becoming increasingly depleted, making the Pekanbaru City government plan to change the city concept to a "City in a Garden", and this will be pursued until 2024. The location for further green open space can be identified to be more effective in reducing temperatures in Pekanbaru City. This priority area analysis was carried out using USGS image data and Geographic Information System (GIS) processing. The calculated data are NDVI, Surface Temperature (LST), Air Temperature, Relative Humidity (RH), and also the THI thermal comfort index for the people of Pekanbaru City.

Keywords

green open space; temperature;
geographic information system;
landsat imagery



I. Introduction

In 2017 the Mayor of Pekanbaru issued a Letter of Interest in Participating in the Green City Development Program (P2HK). The letter stated that Pekanbaru is ready to fulfill the mandate of law number 26 of 2007. The city government will form a self-management team for the implementation of activities, and is ready to issue a APBD for implementation and is ready to draw up a Green City Action Plan (RAKH) (Surat Mayor of Pekanbaru 760/PUPR/ 58).

In the copyright website regarding the P2HK concept, there are eight attributes saying there are eight attributes of a Green City, one of which is Green open space, which means realizing a network of green open spaces, (Green City Development Concept - Green City 2015). The Green City Action Plan is currently under discussion, as reported by the Riau provincial government website, what has been determined is that in order to realize the goal of Riau Hijau in the second mission of the Riau Province RPJMD in 2019-2024, it is necessary to prepare the Riau Green document (IT Bappeda Riau Province 2020).

The rapid growth of Pekanbaru City has the potential to shift the existence of green open space in the city

Pekanbaru. In the evaluation of the Pekanbaru City General Spatial Plan (RUTR) in 1991, the direction of non-built areas, especially those that act as protected areas in 2015 was identified in the Pekanbaru City RUTR covering an area of 16, 768 Ha. The reality is that in 2006 the new protected area reached 2, 487.65 Ha. In the expedition to develop the

protected area of Pekanbaru City until 2015, there has been a change of land use for the protected area into a built-up area such as settlements, trade, industry, plantations, and shrubs. This protected area is secondary forest. The shift in the existence of green open space in Pekanbaru City can make Pekanbaru City uncomfortable, one of which is indicated by the high temperature in Pekanbaru City reaching 34 o C - 35 o C (Noer Aini et al. 2015), construction of shop houses (ruko) (Riatno and Mashur 2017) followed by the addition of houses and housing complexes (Fitri 2011). The city of Pekanbaru is also experiencing the development of a transportation system, especially transportation in the 4.0 era which is growing (Badri 2019). Development is a systematic and continuous effort made to realize something that is aspired. Development is a change towards improvement. Changes towards improvement require the mobilization of all human resources and reason to realize what is aspired. In addition, development is also very dependent on the availability of natural resource wealth. The availability of natural resources is one of the keys to economic growth in an area. (Shah, M. et al. 2020)

For 2021, the capital city of Riau Province has an area of about 63,901.54 hectares (ha), consisting of non-urban areas of 8.970 hectares and urban areas of 54.93 hectares. If referring to the Spatial Planning Law, Pekanbaru City should have 12,780,31 ha of green open space to meet the figure of 30 percent of the city area. However, currently Pekanbaru only has 3,195.08 hectares of green open space, which consists of green lanes, cemeteries, city parks, urban forests, and median road parks (Tempo.co 2021).

Green open space is important to address climate issues, especially in developing cities (Ridwan and Muharoroh 2017). Pekanbaru City is the capital of Riau Province with a city area of 63,226 hectares which has rapid population growth, economy, infrastructure, and development (Mashur 2016)

According to the Meteorology, Climatology and Geophysics Agency (BMKG) through the Sultan Syarif Kasim II Meteorological Station, the change in the average temperature of Pekanbaru City in 1996 - 2016 was quite volatile. This can be seen from the increase and decrease that occurred several times, however, the trend is up. From 1996 to 2016, the increase in temperature was 0.85oC, from 26.73oC to 27.58oC. The phenomenon of Urban Heat Islands in Pekanbaru City has also started (Ikhwan and Hadinoto 2015) .

The temperature in Pekanbaru City has the potential to continue to increase due to daily urban and human activities that produce carbon dioxide (S Suryansayah 2019) . The maximum temperature in Pekanbaru City has also reached extreme temperature levels several times. From the BMKG data, the highest temperature experienced by Pekanbaru City reached 39oC, far above the average temperature of 27.22oC. This includes extreme temperatures based on the Standard Operating Procedures for the Implementation of Early Warning, Reporting, and Dissemination of BMKG Extreme Weather Information (Wiweka 2014)

Determination of Green Open Space can be done using remote sensing methods. One of the remote sensing methods used is to calculate the Normalized Difference Vegetation Index (NDVI) value which is sensitive to the presence of chlorophyll (Ridwan and Muharoroh 2017) and can also use RVI for vegetation density (Xue and Su 2017). From the analysis conducted in 2016, it was found that all public green open spaces in Pekanbaru City are included in the class 1 vegetation density, namely the density of rare vegetation. The basic green coefficient area of the public green open space is almost the same as the existing pavement area (Astaman 2018).

Studies on urban climate show the impact of human behavior on human health (Edmondson and Levy 2013), including outdoor thermal comfort (Xi et al. 2012), climate efficiency (Nouri et al. 2018), and building maintenance (Alur and Deb 2010), use of

public space (Akpinar 2017), quality of life (Cheesbrough et al. 2019), and so on. Therefore, it is important to consider the climate in urban planning for its residents (A et al. 2013), so that in this study the priority of green open space is needed to be a suggestion for the placement of green open space in order to achieve the city in a park that is aspired by the city government.

II. Research Method

This study uses primary data and secondary data. Primary data was obtained by conducting field surveys and processing data from Landsat images. Meanwhile, secondary data was obtained by conducting a literature study.

2.1 Image Data Collector

The image data used was taken from the USGS website in 2021 with the least cloud data. Processing of Landsat 8 OLI/TIRS raster data (path / row: 127/060) using ArcMap 10.3 software. The results of this data processing are in the form of land cover maps of Pekanbaru City, the area of each green open space and vegetation density in Pekanbaru City, distribution of LST values, distribution of air temperature, distribution of relative humidity, and distribution of *Thermal Humidity Index* (THI) in Pekanbaru City.

2.2 Data Processing

1. Identification of Land Cover

Land cover analysis was carried out by processing Landsat imagery using ArcMap. Image processing includes compilation bands, geometric corrections, guided classification subsets, and accuracy tests that produce land cover in the form of built-up areas, bodies of water, vacant land, plantations, and forests.

2. Calculate the value of the *Normalized Difference Vegetation Index* (NDVI).

The Normalized Difference Vegetation Index (NDVI) was calculated to determine the vegetation density index. The NDVI value has a range from -1 to +1 which is calculated using channel 5 and channel 4 (Carlson and Ripley 1997) with the following equation:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Information:

NDVI = Normalized Difference Vegetation Index

NIR = channel 4

RED = channel 5

3. Calculate the *Land Surface Temperature* (LST) value.

Surface temperature is the temperature of the outermost part of an object or surface that gets energy from solar radiation. The surface temperature is obtained by correcting the brightness temperature with different emissivity values for each object (Weng 2001) .

Calculation of surface temperature is carried out with the following equation:

$$LST = \frac{T_b}{(1 + \frac{\lambda T_b}{\rho} \ln \epsilon)}$$

Information:

LST = Surface temperature (K)

T_b = Brightness temperature (K)

wavelength of emitted radiation (11.5 m)

14380 K (derived from hc/σ ; h = Planck's constant (6.26×10^{-34} J s); c = speed of light (2.998×10^8 m s⁻¹); σ = Boltzman's constant (1.38×10^{-23} J K⁻¹))
= Emissivity

4. Calculate the value of Air Temperature.

Solar radiation affects the movement of air molecules. The average kinetic energy of the movement of the molecules is the temperature of the air. Air temperature can be calculated through the following equation (Unsworth 2006)

$$T_a = T_s - \left(\frac{H \times R_a}{\rho_{air} \times C_p} \right)$$

5. Calculating Relative Humidity

The distribution of RH values is obtained from the regression equation between the RH values and air temperature measured in the field directly. The points taken are as many as the points for the accuracy test, which is a minimum of 8n, or 40 points spread over each land cover class (Danoedoro 2015). The collected RH and air temperature data were analyzed to obtain a regression equation for the relationship between air temperature and RH. The equation is then used to calculate the value of the RH distribution (Rusdayanti 2020)

6. Calculate the THI value.

After obtaining the values of air temperature and relative humidity, thermal comfort can be calculated through the Temperature Humidity Index (THI) indicator as follows (Ige *et al.* 2017)

$$THI = 0.8 T_a + (RH \times T_a / 500)$$

Information:

THI = Temperature Humidity Index

T_a = Air temperature (°C)

RH = Relative Humidity (%)

Thermal comfort data by the community was obtained from two previous studies, namely in 2016 (Noer Aini *et al.* 2015) and also in 2019 (Lina *et al.* 2019) so that if accumulated from two previous studies, the THI value for the people of the City Pekanbaru are as follows:

THI	Convenience
23	Very comfortable
25.8	Comfortable
26,20	Quite comfortable
>26,20	Uncomfortable

7. Determine the priority of green space

Determination of green open space has four categories, namely vegetation density, surface temperature, population density (amount per km²), and THI according to people's convenience. According to Table 1

III. Result and Discussion

3.1 Land Cover Map

Pekanbaru City is the capital city of Riau Province which is located between 101°14' - 101°34' East Longitude and 0°25' - 0°45' North Latitude with an altitude of 5-50 meters above sea level. The surface of the northern part of the area is sloping and also wavy with an altitude of 5-11 meters above sea level. Based on the Ministry of Home Affairs Regulation (Permendagri) Number 137 of 2017 which was passed on December 29, 2017, the City of Pekanbaru through Regional Regulation Number 2 of 2020 concerning the Formation of Districts became 15 sub-districts and 83 Kelurahan.

Land cover in Pekanbaru City in this study was divided into five types of land cover modified from a previous study by Astaman (Astaman 2018) which used 2015 image data and classified into four classes, namely built-up areas, water bodies, vacant land, and plantations. Because it has been six years since the researchers found another classification, namely open forest, the previous classification was modified into five land cover classes, namely built-up areas, water bodies, vacant land, and also vegetated areas which were divided into plantations and forests. table 3.

3.2 Pekanbaru City NDVI Value

The high NDVI value in Pekanbaru City, which is $> 0.49-0.6$, is dominated on the outskirts of the city, where oil palm plantations are more dominant in that area. For the value of green open space with vegetation density (NDVI) it is very rare, namely at 16 points (33%), rarely there are 21 points (43%), while there are 11 points (22%), densely absent, and very dense at one point, namely in Forest Pekanbaru City. It's in Figure 2.

3.3 Pekanbaru City Surface Temperature Value

The highest surface temperature in Pekanbaru City in 2015 was 28.9 o C (Atsaman 2019), while in 2021 the highest temperature was 27.8 o C, this is a decrease. The distribution of this surface temperature on several land covers in Pekanbaru City is indeed not varied enough, because areas with low surface temperatures are located on the outskirts of the city or near plantation areas, while in built areas where there are many people living in Pekanbaru City, the temperature is quite high. high, reaching 27.8 o C, in Figure 3.

3.4 Pekanbaru City Air Temperature Value

The distribution of air temperature in Pekanbaru City is divided into a minimum value of 19.7 o C and a maximum value of 56.6 o C, the distribution can be seen in Figure 4. The maximum water body temperature is 26.1 o C and a minimum of 19.7 o C, the maximum vegetation area is 33.5 o C and the minimum is 21.4 o C, and for the non-vegetated area the highest is 56.6 o C and the minimum is 24.8 o C.

3.5 Pekanbaru City Humidity Value

After obtaining the air temperature value, you can also find the value for humidity. The moisture value is obtained from the regression results from several points in different land cover classes. Here the researcher took 47 sample points which were then searched for the regression results.

The regression value is $y = 110-1.9x$, where the correlation value is -0.52 or real. While the Pearson value is 0.0013, with the coefficient of determination (R^2) formed from this simple linear regression equation is 0.27. This shows that almost 30% of the diversity of air humidity values produced can be explained by its linear relationship with air

temperature values, in accordance with the theory that the higher the air temperature, the capacity to store water vapor will increase, so the humidity will be low if the temperature is higher. the air temperature increases and vice versa, the humidity will be higher if the air temperature decreases (Handoko 1995). The distribution of Pekanbaru City's Relative Humidity can be seen in Figure 5 where when identified with the relative humidity category by (Sitanggang 2020) then the entire city of Pekanbaru is in the dry category, because the highest value is only 70.7%.

3.6 The Value of THI for the People of Pekanbaru City

Figure 6 shows that there are still many comfortable areas in Pekanbaru City, but these areas are filled with oil palm plantations, and in areas where many people live, some are uncomfortable, especially in the middle of Pekanbaru City.

3.7 Pekanbaru City Green Open Space Priority

To identify the priority areas of green open space, a scoring is carried out where the values of NDVI, LST, Air Temperature, Humidity, THI values are added up. As in Table 1.

It can be seen from Figure 7 that the priority of green open space is with the lowest score between the 12-19 ranges. For 12-15, the most priority areas are in Pekanbaru Kota, Sukajadi, and Sail sub-districts. Meanwhile, the sub-districts that are not prioritized are East Rumbai, West Rumbai, and Tenayan Raya districts.

According to the RTRW of Pekanbaru City for 2020-2040 the Tenayan Raya area and the Rumbai sub-district area later, although it is not currently a priority area for green open space, it will become an industrial area as well as for settlements, so it must be prepared early on for its green area so that Pekanbaru's dream is to become a city. In the Garden can be realized.

3.8 Recommended green space design for Pekanbaru City

There are several theories that aim to increase green open space in urban areas, namely by increasing the shaded area to reduce air temperature from 0.33 to 0.84 °C because it increases humidity and reduces solar radiation (Saputro et al. 2010) ; reducing pavement area to reduce air temperature (Bernatzky 1978) , plant-covered walls can reduce surface temperature (Pérez-Urrestarazu et al. 2015) , avoiding complex green open spaces can reduce temperature (Naeem et al. 2018) ; reducing paved areas and replacing them with green areas can reduce the effects of heat due to climate change (Vargas-Hernández et al. 2018) high temperatures are caused by CO pollutants, so plants that have a high ability to absorb CO are needed, namely the type of tree is the Ganitri plant (*Elaeocarpus sphaericus*), the type of shrub, namely Iriansis (*Impatien* sp), and the bush *Philodendron* (*Philodendron* sp) (Kusminingrum 2008) , paving blocks have the highest water absorption ability compared to other pavement materials (Andini 2016) , the addition of water elements can absorb heat more and store it for a long time before being released (Kusminingrum 2008) and able to absorb pollutants (Nugroho 2015) . In the Regulation of the Minister of Public Works Number: 05/PRT/M/2008 regarding guidelines for the provision and utilization of green open spaces in urban areas, it can also be a guide book to improve the quality of green open space.

Table 1. Indicators for Determining the Priority of Pekanbaru City Green Open Space

No	Indicator	Criteria	Score
1	Vegetation Density (NDVI)	0 – 0.2	1
		0.2 – 0.4	2
		0.4 – 0.6	3
		0.6 – 0.8	4
		> 0.8	5
2	Surface Temperature (LST)	>28.9 °C	1
		24 °C-28.9 °C	2
		<24 °C	3
3	Population density	<2500	8
		2,500 – 4,999	7
		5,000 – 9,999	6
		10,000 – 14,999	5
		15,000 – 19,999	4
		20,000 – 24,999	3
		25,000 – 29,999	2
		> 30,000	1
4	Relative Humidity	< 70.0	1
		70.0 to < 75.0	2
		75.0 to < 80.0	3
		80.0 to < 85.0	4
		85.0	5
5	Air temperature	< 21.1	7
		21.1 to < 23.1	6
		23.1 to < 25.1	5
		25.1 to < 27.1	4
		27.1 to < 29.1	3
		29.1 to < 31.1	2
		31.1	1
6	Thermal Comfort	Very comfortable	4
		Comfortable	3
		Quite comfortable	2
		Uncomfortable	1

The data source is processed from the results of the BLKMP test

Table 2. Pekanbaru City Population Density

Subdistrict	Total population	Percentage	District Area (Km ²)	Population Density (Per Km ²)	Score
Umbrella	89309	8.98%	35.55	2512	7
Tuahmadani	142464	14.32%	29.84	4774	7
Binawidya	72614	7.30%	36.59	1985	8
Flat Hill	93712	9.42%	22.05	4250	7
Peaceful	127897	12.86%	29.74	4301	7
Marpoyan					
Happy Raya	103899	10.45%	114.4	908	8

Kulim	53898	5.42%	56.87	948	8
Fifty	38647	3.89%	4.04	9566	6
Sail	20402	2.05%	3.26	6258	6
Pekanbaru	22624	2.27%	2.26	10011	5
City					
happy	42889	4.31%	3.76	11407	5
guns	35388	3.56%	6.65	5322	6
Tassel	92195	9.27%	61.86	1490	8
Western	25205	2.53%	86.01	293	8
Tassel					
Eastern	33442	3.36%	138.31	242	8
Tassel					
Total	994585	100.00%	631.19		

The data source is processed from the results of the BLKMP test

Table 3. Pekanbaru City Land Cover Area Table

Table 3.1 Peninsular City Land Cover Area Table							
Land Cover	Score	2015		2020		2021	
		Area (ha)	Percent	Area (ha)	Percent	Area (Ha)	Percent
Built-up Land	0	13593,72	21.3%	14874.76	23.3%	16768.71	26.3%
Water body	1	569.25	0.9%	843.74	1.3%	1117.71	1.8%
Empty land	2	3290.83	5.2%	1520.37	2.4%	1726,14	2.7%
Plantation	3	44677.8	70.0%	44192.78	69.2%	40182.19	63.0%
Forest	4	1699,366	2.7%	2399,316	3.8%	4036.22	6.3%
Total		63830.97	100.0%	63830.97	100.0%	63830.97	100.0%
Over All Accuracy*		87%		90%		88%	
Kappa Coefficient		93%					

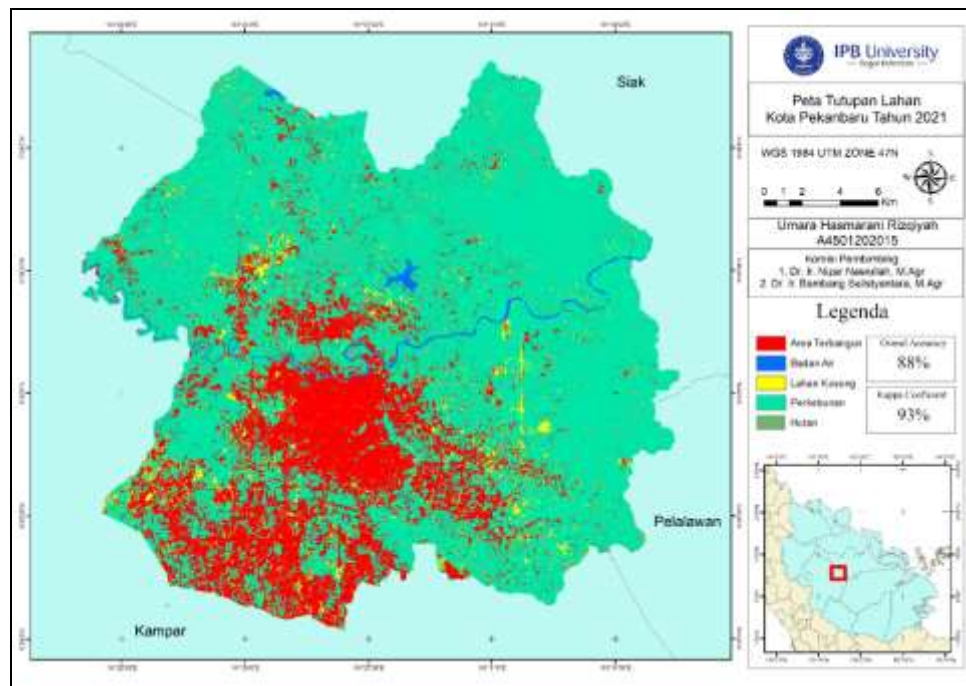


Figure 1. Pekanbaru City Land Cover 2021

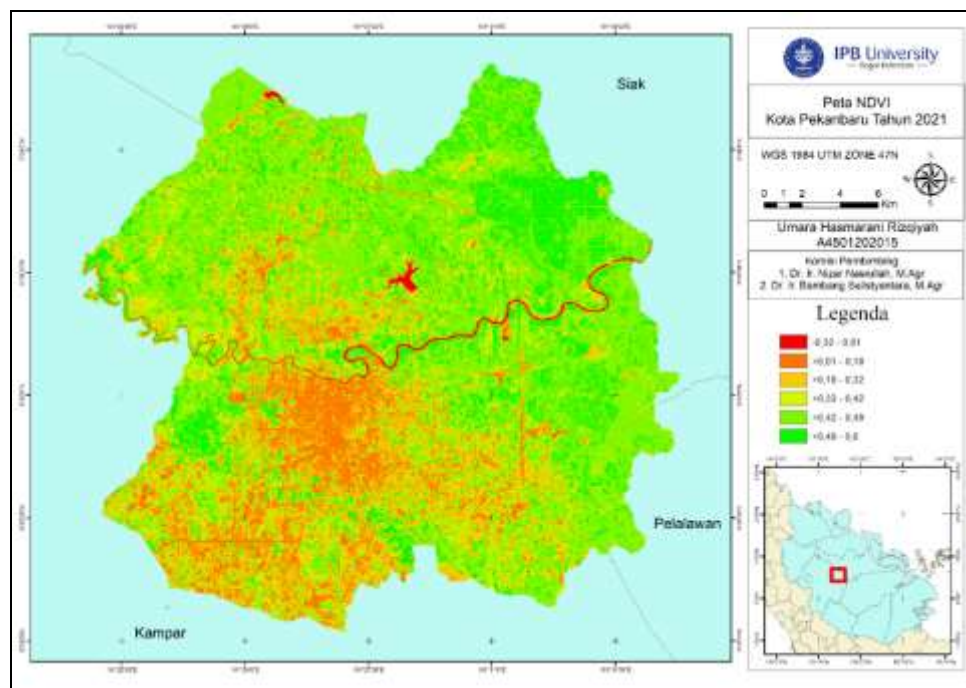


Figure 2. NDVI Pekanbaru City 2021

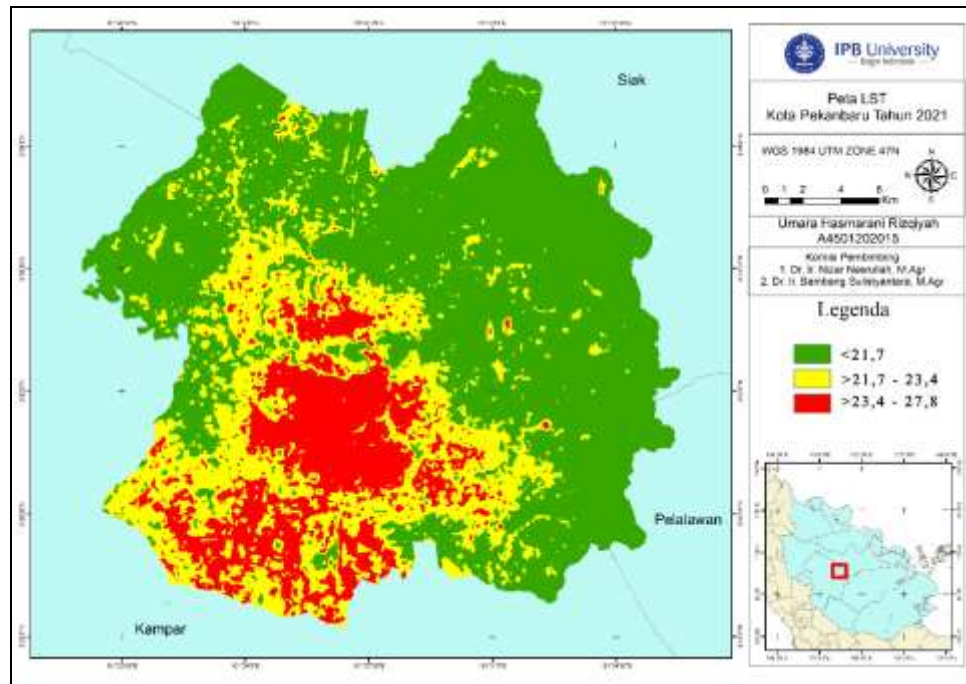


Figure 3. Pekanbaru City LST 2021

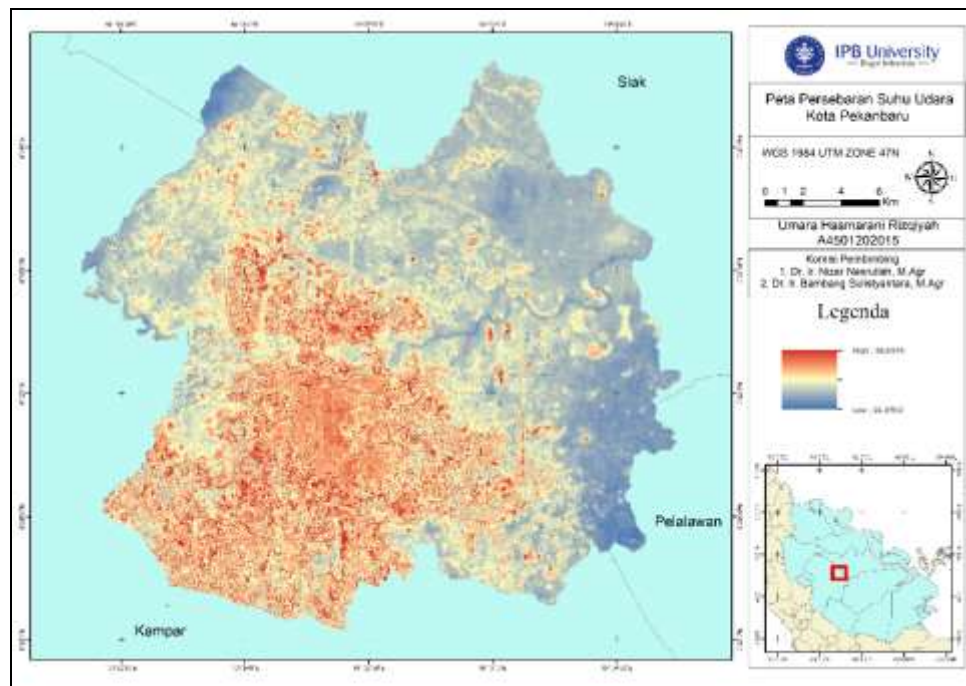


Figure 4. Pekanbaru City Air Temperature 2021

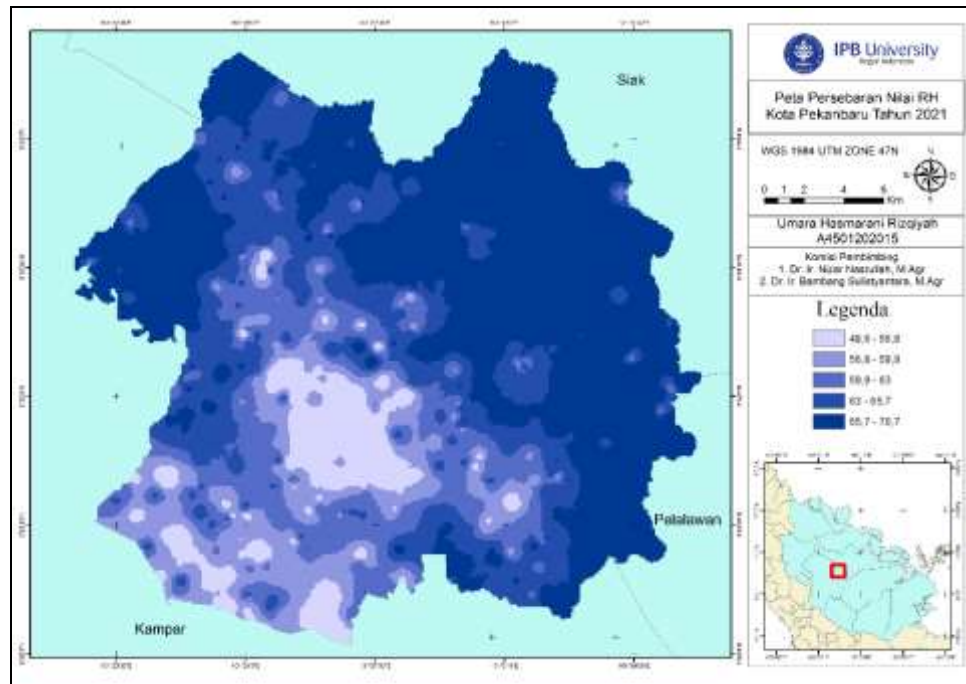


Figure 5. Pekanbaru City Relative Humidity 2021

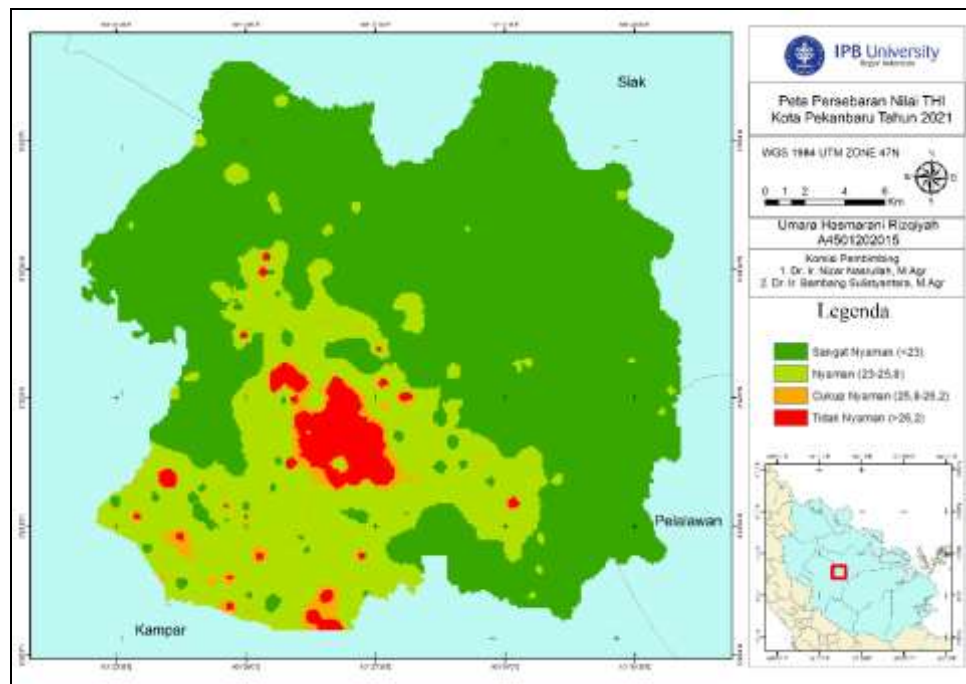


Figure 6. Pekanbaru City Relative Humidity 2021

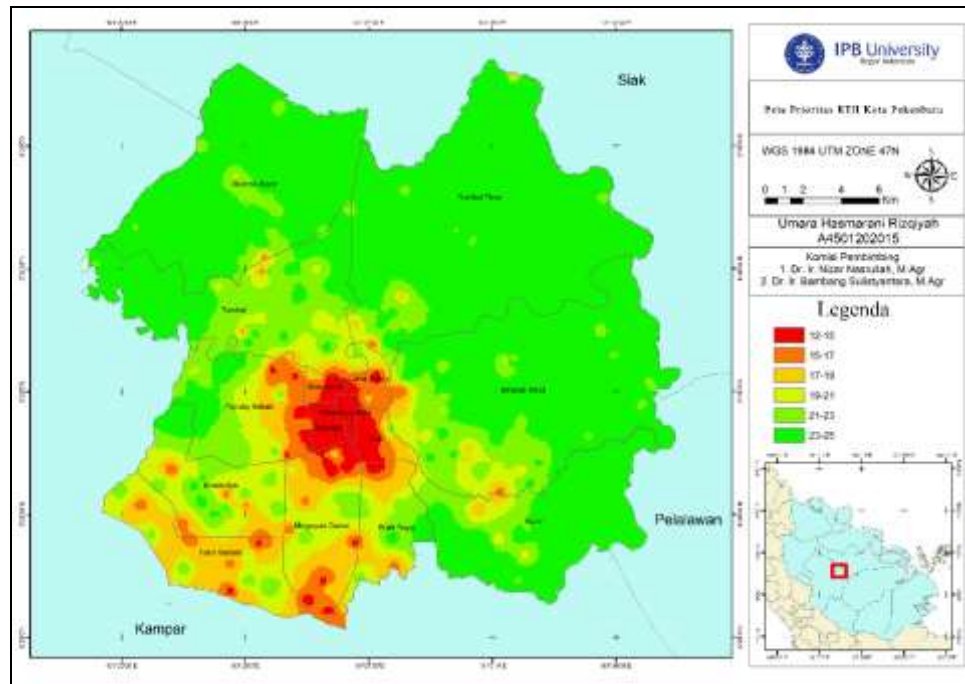


Figure 7. Pekanbaru City Green Open Space Priority

IV. Conclusion

Pekanbaru City to create a City in a Park, it must improve the quality of green open space in the city. The placement of the location of green open space is also not just as long as it is placed, and the sub-districts that are the priority for the next green open space are in the Pekanbaru Kota, Sukajadi, and Sail sub-districts, while the sub-districts that are not priority are the East Rumbai, West Rumbai, and Tenayan Raya sub-districts. but because according to the RTRW of Pekanbaru City in 2020-2040 the area will later be for industrial areas and also residential areas must be carefully planned, especially for city green open space.

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